The Tidal Creeks Project

Understanding Our Coastal Waterways

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Preface

Researchers initiated the Tidal Creeks Project to understand how land development affects the environmental quality of ***tidal creeks*** as well as to share project results with local and state land use planners and regulators. Their results suggest that when the amount of ***impervious cover*** – roofs, parking lots, roads – is about 20 percent, the physical, chemical, and biological processes in these habitats is altered in a manner that makes them less suitable nurseries for fish and shellfish. Based on this information, researchers present a conceptual model that explains the relationship between landscape development and the health of creeks. They also recommend ways we can conserve these scenic and productive ecosystems for future generations to use and enjoy.

Figure 1: Tidal creeks draining a Charleston shipyard and industrial site.

Valuing South Carolina's Tidal Creeks

Our coastlines are alluring places for millions of people, residents and visitors alike. In fact, 50 percent of the U.S. population lives in ***coastal counties***, which account for less than one fifth of the nation's land area. We enjoy and benefit enormously from our oceans, estuaries, tidal creeks, and salt marshes. These environments provide us with recreation, seafood, and commerce and help process our waste. Southeastern tidal creeks are particularly popular locations for building homes, resorts, and recreational facilities. However, recent studies suggest the environmental quality in the creeks affects our property values, economy, and health.

Large amounts of impervious cover – roofs, parking lots, and roads – in the drainage basin could be a threat to the health of our creeks. For instance, Charleston's urban area increased 250 percent in 20 years while the human population only increased 40 percent. The amount, timing, and quality of the stormwater runoff from this type of rapid ***watershed*** development carries sediments, chemicals, bacteria, viruses, and other pollutants into tidal creeks. These pollutants come from many hard to identify sources, sometimes called ***non-point source pollution***, and degrade tidal creek water quality. Chemicals also accumulate in sediments to levels that can harm marine life. Swimming in creeks with degraded water quality or eating fish and shellfish from degraded creeks may adversely affect public health.

"Many have the attitude toward development that we once had toward smoking: sure it's bad, but it won't be a problem for me." – *Anna Quindlen's article,* Put 'Em in a Tree Museum

Tidal creeks are critical aquatic nurseries. They provide refuge for juvenile fish, shrimp, and crabs and supply us with seafood. Spotted sea trout, spot, croaker, white and brown shrimp, and blue crabs are some of the economically important creek inhabitants in the Southeast. South Carolina's coastal economy, which especially depends on keeping our tidal creeks clean and healthy, accounted for $40 billion in economic output in 2000 and 25 percent of all state employment growth. Nationally, coastal resources annually contribute hundreds of billions of dollars to the U.S. economy.

Figure 2: White shrimp are abundant and commercially important inhabitants of southeastern tidal creeks.

In the Southeast, local and state governments will be responsible for approving almost every aspect of coastal development over the next several decades. As a result, a handful of public officials will control what coastal development looks like and how it affects the environment. If these officials and the governments they represent continue to support a sprawl-like growth pattern, then tidal creek productivity, quality, beauty, and services will degrade – possibly forever. We must address how coastal development should proceed if the valuable, natural resources are to be sustained.

Understanding the Tidal Creeks Project

Researchers initiated the Tidal Creeks Project to better understand how land development affects the environmental quality of tidal creeks. Researchers sampled 40 to 50 tidal creeks over the last 10 years and used the amount of impervious cover to measure the degree of watershed development associated with each creek. The creeks were representations of different amounts and types of development, from undeveloped, forested areas to suburban, urban, and industrial areas. Undeveloped or forested watersheds had less than 10 percent impervious cover in their watersheds, suburban watersheds had 11 to 50 percent impervious cover, and urban and industrial watersheds had more than 50 percent impervious cover.

Figure 3: Tidal Creeks Project researchers sampled many creeks in the Charleston area.

Tidal Creeks Project Objectives

"If today's land consumption trends continue, more than one-quarter of the coast's acreage will be developed by 2025 – up from 14 percent in 1997." – Dana Beach's Coastal Sprawl: The Effects of Urban Design on Aquatic Ecosystems in the United States

The Tidal Creeks Project had four primary objectives:

1. To identify the effects different kinds and levels of watershed development have on the ability of tidal creeks to serve as nursery habitats

2. To evaluate the degree to which the amount of impervious cover is associated with degraded conditions in creeks and is a measure of watershed degradation

3. To create a conceptual model that visually represents how tidal creeks respond to land development

4. To use the conceptual model to develop recommendations for conserving and restoring tidal creek health.

Researchers collected landscape, water quality, sediment quality, and biological data about tidal creeks and their watersheds.

What the Project Measured

To accomplish their objectives, researchers determined land use patterns in each creek's watershed; estimated the amount of impervious cover in the watersheds; and measured water quality, ***fecal coliform*** bacterial levels, chemical levels in sediments, and kinds and abundance of aquatic life in creek water and sediments.

Relating the Project's Data to a Conceptual Model

Researchers developed a three-part conceptual model to describe and explain the connection between human population density (the ***stressors***) and physical and chemical changes in the environment (the exposures) as well as changes in a tidal creek's capacity to serve as a nursery habitat and provide other societal benefits (the responses). This model is also helpful for assessing the risks of future development.

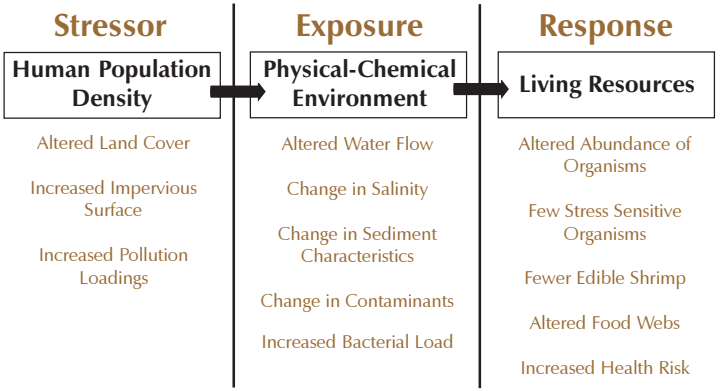

Figure 4: The Tidal Creeks Project three-part conceptual model explains how human population density is linked to the environment and organisms.

Tidal Creek Stressors

Coastal population growth was the major stressor to tidal creeks. Growth stress was measured by increases in population density and the amount of impervious cover in a watershed. During the study period, forested and agricultural lands continued to be converted into suburban and urban areas at twice the rate that the population was growing.

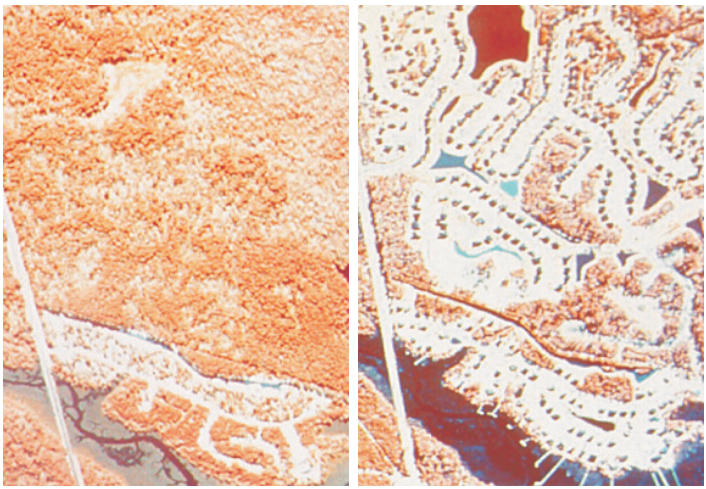

Figure 5. The result of rapid development in Horlbeck Creek at the beginning of development in 1992 and after development in 1999.

Researchers found that forested watersheds had little or no impervious cover in their watersheds. In contrast, impervious cover averaged 30 percent in suburban watersheds and more than 67 percent in urban watersheds. The amount of impervious cover increased in suburban and urban watersheds by about 10 percent over a seven-year period. That rate of increase in impervious cover is projected to continue into the near future.

Environmental Exposures

When the amount of impervious cover exceeded 10 to 20 percent in a watershed, researchers detected changes in stormwater runoff, salinity, chemical contaminants in sediments, and fecal coliform bacterial levels.

Increased stormwater runoff

When a watershed's topography changed and the amount of impervious cover increased, stormwater runoff was more episodic or 'flashier,' and a larger amount of polluted water was released into creeks. For instance, a one-acre parking lot produces 16 times the runoff as a one-acre meadow. In contrast, forested environments reduce the amount and rate of runoff and the pollutants the runoff contains. When stormwater is allowed to infiltrate into soil, many pollutants become trapped and many are transformed into harmless decay products by natural chemical and biological processes.

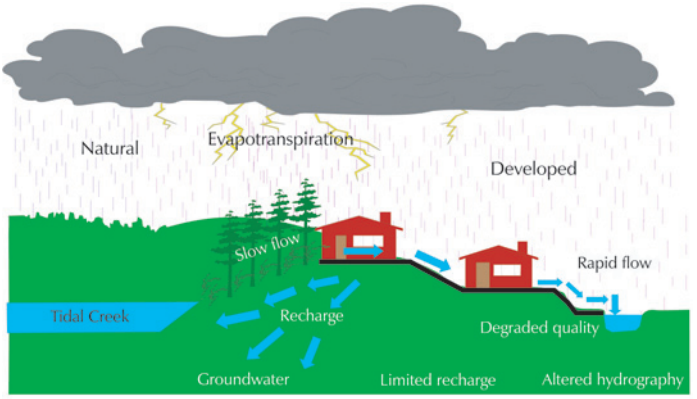

Figure 6. Runoff in natural versus developed watersheds.

As the amount of impervious cover increased, the volume and rate of stormwater runoff and the amount of pollutants that reached the creeks increased. In a forested setting, only about 10 to 20 percent of rainfall on the watershed returned to tidal creeks as surface runoff. In suburban and urban areas, researchers estimate that about 15 to 75 percent of rain that fell on the watershed returned to the tidal creeks as stormwater surface runoff. The highest runoff occurred in urban watersheds and the lowest in forested and low-density suburban watersheds.

Highly variable salinity

Maintaining a relatively stable salinity regime, or the amount of salts in water, is an important characteristic of tidal creek nursery habitats. Sensitive, early-life stages of fish, shrimp, and crabs were not as abundant in environments with extreme and unpredictable salinity fluctuations. Salinity variability increased when impervious cover exceeded 10 to 20 percent. Researchers observed highly variable and erratic salinity fluctuations in suburban and urban environments during the critical summer nursery period.

Increased chemical contaminants

Sediment pollutants were slightly higher in suburban creeks than in forested creeks. However, sediment trace metal concentrations (copper, cadmium, lead, zinc, and mercury) were two to 10 times higher in urban and industrial creek sediments than in suburban and forested creeks. Urban and industrial creeks also had substantially higher organic contaminants, including products from vehicle exhausts, such as ***polycyclic aromatic hydrocarbons*** (PAHs).

Increased fecal coliform bacteria

Most states close shellfish grounds to harvesting when the number of colony-forming fecal coliform bacteria exceeds about 20 counts per 100 ml of water, and water contact recreation is generally prohibited when fecal coliform levels exceed about 200 counts per 100 ml. Humans typically contract waterborne pathogens from eating filter-feeding shellfish and swimming.

The level of fecal coliform contamination increased when the amount of impervious cover increased in tidal creek watersheds. Most of the sampled creeks did not meet the fecal coliform standard for shellfish harvesting or swimming, including most of the undeveloped, forested creeks. Wildlife caused most of the high fecal coliform contamination at these forested sites, and the high fecal coliform levels in suburban areas were most likely due to pets. Extremely high fecal coliform levels in urban creeks were undoubtedly from multiple sources, including human sewage.

Biological Responses

Organisms living in tidal creeks respond to increases in pollution associated with development in a variety of ways. The abundance of pollution-sensitive animals, such as edible shrimp and some bottom-dwelling prey of juvenile fish, decreased as pollution levels and impervious cover increased. Conversely, the abundance of pollution-tolerant organisms increased as development and pollution levels increased. Pollution-tolerant worms were very abundant in urban and industrial creeks, which had extremely simple food webs and very low amounts of edible shrimp. The effects from development were most apparent on biological resources when the amount of impervious cover in watersheds exceeded 30 percent.

"Almost one-third of South Carolina shellfish harvesting areas are closed because the consumption of oysters from these areas could pose health risks."
Lewitus and Mallin

Considering Project Conclusions and Recommendations

The Tidal Creeks Project's message is straightforward: The kinds and levels watershed development greatly influence the amount of stormwater runoff and pollution that is released into creeks. Poorly planned or sprawling development patterns that create large amounts of impervious cover in tidal creek watersheds adversely affect these critical nursery habitats and cause:

- Episodic or 'flashy' runoff (indicates the extent to which natural creek flow has been altered)
- Increased amounts of chemicals in creek mud (indicates the extent of chemical contamination and pollution)
- Increased fecal coliform bacterial levels (indicates the degree to which swimming and shellfish harvesting have been affected)
- Changes in the kinds and abundance of food web organisms (indicates effects on creek food webs)
- Decreased abundance of harvestable shrimp (indicates the degree to which nursery grounds have been harmed).

A concerted public education effort could foster and encourage permanent protection of watersheds and the critical services they naturally provide. Additionally, the best strategy for conserving tidal creek environmental quality is planning development at regional, neighborhood, and site scales.

Regionally, infrastructure planning and zoning are the most effective approaches for determining where new development should occur; however, zoning and ordinances only protect the land until the next Land Use Plan or until a new local authority is elected.

At the neighborhood scale, ***Purchase of Development Rights*** (PDR) programs and land easements effectively provide relatively permanent land protection. Designs that maximize street connectivity and open space should be encouraged or even required. These clustered designs will minimize vehicle use and improve the quality of life as well as sustain the environmental quality of tidal creeks.

At the site scale, guidance should minimize the amount and maximize the quality of stormwater runoff. This can be accomplished by:

1. Minimizing the amount of new impervious cover that is created

2. Directing surface water runoff into ***swales*** and ***vegetated buffers*** to trap pollutants and increase infiltration allowing slower return to creeks

3. Maintaining vegetated open spaces and buffers to decrease the amount and rate of runoff and improve the quality.

In conclusion, tidal creeks are sentinels that provide early warning of the degree to which land development affects coastal environmental quality. We must become stewards of our creeks and marshes.

"The simultaneous pursuit of economic prosperity and environmental stewardship are not contradictory or mutually exclusive. This common vision will need enlightened leadership from across the political spectrum to realize the vision of coastal growth and stewardship." – A final report from the Council on Coastal Futures

Recommendations for Local and State Land Use Planners and Regulators

- Plan development activities that:
  - Limit alterations to freshwater inflows
  - Minimize the amount of impervious surface
  - Require vegetated buffers
  - Maximize the amount of vegetated open space
- Prepare and publish guidance and standards for development that prevent pollution from entering valuable tidal creek habitats.
- Evaluate development on a watershed basis.
- Create a land conservation ethic that encourages stewardship of tidal creeks.
- Limit the amount and kind of pollutants released into tidal creeks.
- Establish permanent land trusts for critical habitats within tidal creek watersheds.
- Periodically monitor and assess the status and trends of tidal creeks and report their condition to the public.

Contact the South Carolina Sea Grant Consortium for a free copy of *South Carolina Coast-A-Syst: An Environmental Risk-Assessment Guide for Protecting Coastal Water Quality.*

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Seeking Additional Resources

Many organizations have supported the Tidal Creeks Project or are conducting related research. Get to know local and national affiliates and studies related to tidal creeks:

- **The National Oceanic and Atmospheric Administration** (NOAA) is a federal agency whose mission is to understand and predict changes in the Earth's environment as well as conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs. Visit NOAA online at www.noaa.gov.

- **The South Carolina Department of Natural Resources** (SCDNR) is a state agency that is an advocate for and steward of the state's natural resources by helping regulate fishing, boating, and hunting. Visit SCDNR online at www.dnr.state.sc.us.

- **The South Carolina Office of Coastal and Resource Management** (OCRM) is a state agency that is responsible for protecting South Carolina's coastal environment while promoting responsible development along the state's coast. Visit OCRM online at www.scdhec.net/ocrm.

- **The Charleston Harbor Project** (CHP) was a comprehensive resource management-planning project for the greater Charleston Harbor watershed. The project provided community leaders and managers with information to make decisions that accommodate the area's rapid population growth as well as maintain its rich economic, cultural, and natural history. Visit CHP online at www.scdhec.net/eqc/ocrm/HTML/chp.html.

- **The South Carolina Sea Grant Consortium** is a state agency that enhances economic opportunities and conserves coastal and marine resources through research, educational, extension, and training programs. Contact Sea Grant for a homeowner's water quality guide, *Coast-A-Syst*. Visit the Sea Grant Consortium at www.scseagrant.org.

- **The Southeast Fisheries Science Center** (SFSC) is a multi-disciplinary research organization that provides management information to support regional and national programs of the National Marine Fisheries Service. Visit SFSC at www.sfsc.noaa.gov.

- **The South Atlantic Bight Land Use-Coastal Ecosystem Study** (LU-CES) is an interdisciplinary Sea Grant research program that is designed to understand the effects of changing land use patterns on coastal resources. Visit LU-CES online at www.lu-ces.org.

- **The Urbanization and Southeastern Estuarine Systems Project** (USES) is an ongoing study assessing and modeling the effects of urban development on small, high salinity estuaries on the Southeastern coast of the United States. Visit USES online at www.urbanestuary.org.

- **The Council on Coastal Future's Final Report 2004**, *Setting a New Course for the Coast*, recommends ways to preserve the valuable coast. Visit the Council's Web site for a copy of the report at www.scdhec.net/ocrm/html/ccf.html.

Glossary

- **Coastal watershed counties** have at least 15 percent of their land area in a coastal watershed.

- **Ecosytems** are systems formed by complex communities of organisms and their physical environment.

- **Estuaries** are diverse, semi-enclosed coastal bodies of water where seawater and freshwater mix.

- **Fecal coliform** bacteria are a subgroup of total coliform bacteria, which are a collection of microorganisms that live in human as well as warm-and cold-blooded animals' intestines. High fecal coliform concentrations can indicate the presence of harmful viruses and bacteria, like *E. coli*.

- **Impervious cover** is the percentage or ratio of paved or hardened surface relative to the total land area. Types include roofs, roads, parking lots, and other hard materials that water cannot penetrate. Impervious cover is not the same as developed land cover, though. The Department of Agriculture (USDA) defines developed land as urban or suburban, which includes porous surfaces such as lawns and golf courses.

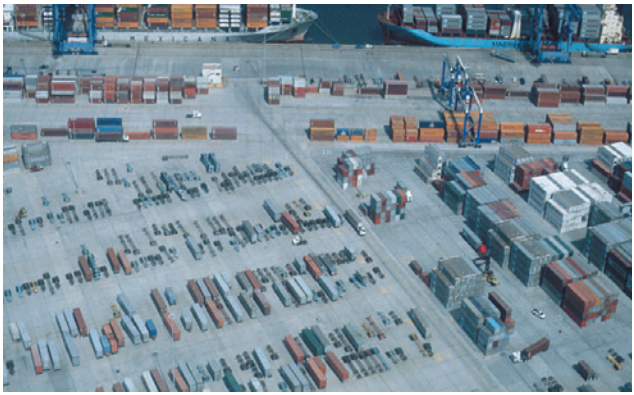

Figure 7: An example of 100 percent impervious cover.

- **Non-point source pollution** cannot be traced to a specific source but comes from multiple generalized sources, such as farmlands and parking lots, and drains into watersheds and bodies of water.

- **Polycyclic aromatic hydrocarbons** (PAHs) are a group of over 100 different chemicals that are formed when coal, fossil fuels, or garbage do not burn completely.

- **Purchase of Development Rights** (PRD) programs channel development from rural areas by using public funds to purchase the rights to a particular piece of property.

- **Stressors** are agents that cause stress to an organism.

- **Swales** are low, narrow tracts of land that tend to be marshy and moist.

- **Tidal creeks** connect uplands and marshes to estuaries.

- **Vegetated buffers** slow down stormwater runoff, promote groundwater recharge, and filter pollutants.

- **Watersheds** are the entire area surrounding a particular body of water – streams, rivers, ponds, and lakes – into which runoff drains.